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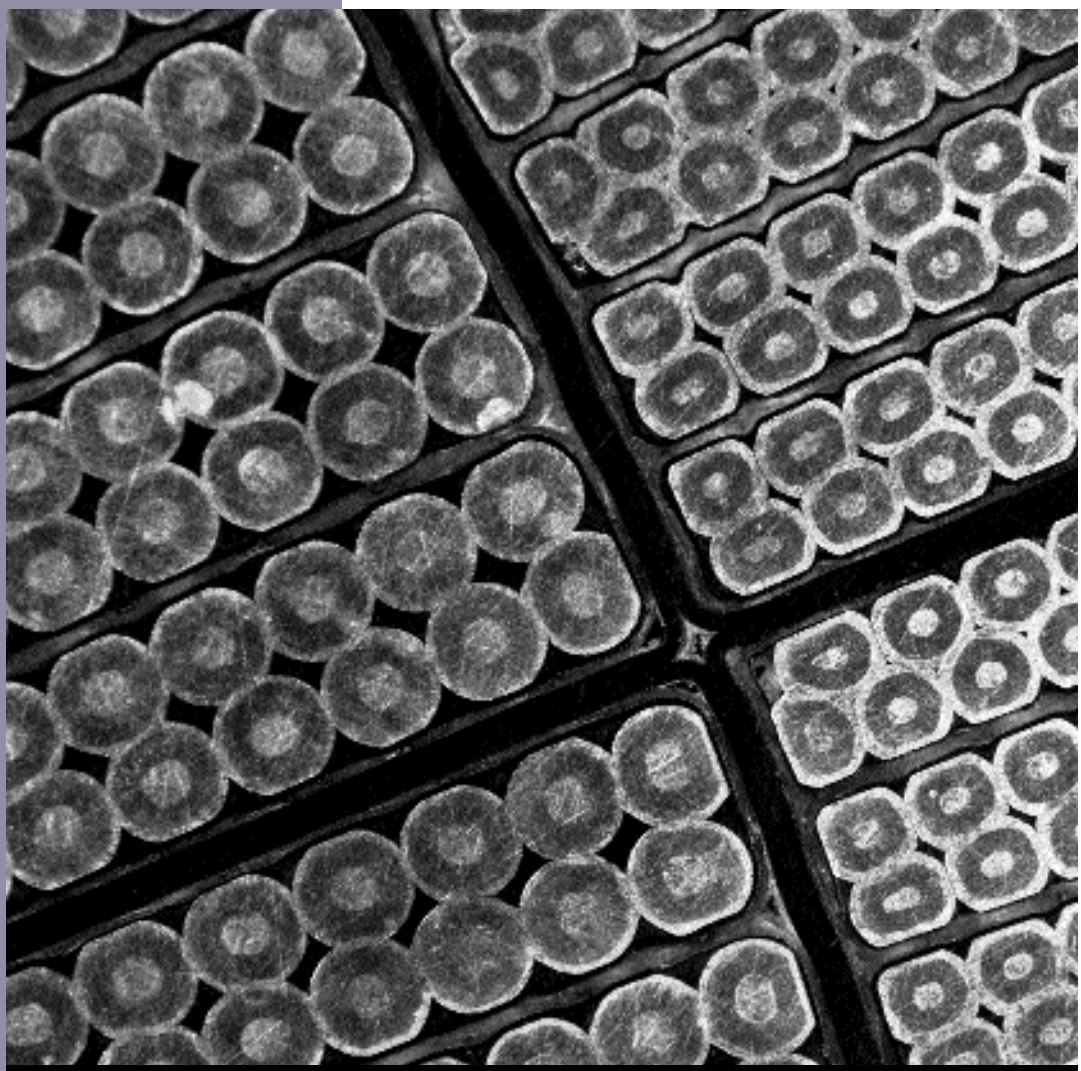

Photo by Reidar Hahn

SUPERCONDUCTING ISSUE

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INSIDE:

Superconductivity:

Photo by Reidar Hahn

by Peter J. Limon
Fermilab Technical Division Head

Technological advances have always driven science. Consider the moons of Jupiter.

Galileo's observations of four Jovian moons in 1610 heralded a new age of science, with the birth of modern astronomy. Galileo capitalized on that era's technological advances in lens grinding, leading to the development of the telescope—which Galileo did not invent, but which he improved greatly through his own precise and methodical work.

Galileo is considered by many to be the founder of modern science, so we can say that from the very beginning scientists have used technological advances to break new ground in understanding the fundamentals of nature. Telescopes, microscopes, computers, and, of course, particle accelerators are all technological advances that have pushed science forward, and, in turn, benefited from science, too.

Superconductivity is another good example.

Without this remarkable ability of some materials to conduct electricity unimpeded, we could not think about high-energy physics as we do today —or as we will tomorrow. With superconductivity, we have imagined and developed the large accelerators and colliding beams that promise to take us beyond the borders of the Standard Model: the Tevatron, the Large Hadron Collider, and the machines of ensuing generations. It's interesting that superconductivity, which makes possible the modern "microscopes" of high-energy physics, was discovered in Holland, birthplace of the lenses of the 16th century.

Realistically, we couldn't afford any large hadron colliders without superconductivity. Superconducting magnets are less expensive than conventional copper and iron magnets, when their cost is adjusted by their bending capability. The electric bills would be fatal for colliders with conventional electromagnets. Without superconductivity, we would need rings on a colossal scale to compensate for the low fields in conventional magnets. We would not have the pinpoint focusing capability of very strong superconducting quadrupole magnets.

But we must always ask: What's next? We are reaching the limits of the materials that we have up to now used in superconducting magnets. If we want to make stronger magnets we will have to develop new and largely unproven materials. Our next accelerators may be linear accelerators and

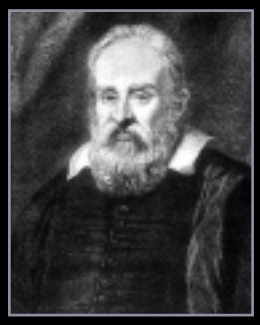
How much can we imagine?

may employ superconducting radiofrequency cavities, an advance more controversial than the corresponding development in magnet technology. While we can easily imagine conventional cavities accelerating electrons to the energies we need for future experiments, we cannot deny some clear advantages to superconducting RF: reduced power losses in cavities, with virtually all the power going into the beam; longer pulses with greater numbers of electrons; a more efficient process that does not waste power by heating the walls of the cavities.

The question always arises: what are the applications? Already, superconductivity enhances our medical diagnostic capabilities through magnetic resonance imaging. Fourth-generation light sources, based on superconducting electron linacs, promise unprecedented advances in biology, chemistry and materials science. Before long, we should have commercially feasible high-temperature superconducting power transmission lines, offering great savings in lighting and powering our cities.

From our vantage point in the present, we cannot imagine all the possibilities. Galileo did not imagine 12 more moons of Jupiter, nor could he have imagined the Hubble Space Telescope, or the Sloan Digital Sky Survey. As ever, the future will take us in all the unexpected directions where technology leads—and where, in turn, science leads technology.

Galileo Galilei



From *Siderius Nuncius* (*"The Starry Messenger"*), March 1610:

"About ten months ago a report reached my ears that a Dutchman had constructed a telescope, by the aid of which visible objects, although at a great distance from the eye of the observer, were seen distinctly as if near…"

"At length, by sparing neither labour nor expense, I succeeded in constructing for myself an instrument so superior that objects seen through it appear magnified nearly a thousand times, and more than thirty times nearer than if viewed by the natural powers of sight alone…"

"I therefore concluded, and decided unhesitatingly, that there are three stars in the heavens moving about Jupiter, as Venus and Mercury around the sun…[subsequent] observations also established that there are not only three, but four erratic siderial bodies performing their revolutions round Jupiter…"

"Family portrait" by NASA, of Jupiter and the four Galilean satellites

Photo by Petra Folkerts

TESLA *by* TAXI

DESY presents a proposal for a superconducting accelerator

On the Web: www.desy.de

By Judy Jackson

Hamburg, Saturday, March 24—The TESLA Colloquium and the Test Facility tour at DESY, the *Deutsches Elektronen-Synchrotron*, have ended. A few hours of chilly afternoon daylight remain, enough for a quick sightseeing tour. We take a cab from our hotel near DESY in the near-west Hamburg suburbs and ask the driver, a tall young woman with a warm smile—and, it turns out, a lively curiosity—to take us to the *Rathaus*, the 18th century neo-Renaissance City Hall at the city center. She asks where we're from.

"We're from Chicago."

Is Chicago anything like Hamburg?

Chicago and Hamburg have a lot in common. They're both flat, they're both on the water, they're both cold in March. Also in both Hamburg and Chicago, almost everyone speaks English.

So, are you taking a tour around Germany?

No, we came to visit DESY, the high-energy physics lab in Hamburg.

Ah! There's a big meeting out there this weekend. I've taken quite a few people there. What's happening?

Scientists at DESY held a colloquium to announce a proposal for a new particle accelerator called TESLA that they would like to build here in Hamburg. More than nine hundred scientists came from all over the world to hear about the TESLA Technical Design Report.

DESY photo

Nine hundred people, 40 percent from abroad, attended the TESLA colloquium at DESY-Hamburg on March 23 and 24, 2001.

DESY Director Albrecht Wagner held a press conference to announce the findings of the TESLA Technical Design Report.

Photo by Peter Limon

Design Report?

Five big books with the results of nearly ten years of work and study for a new accelerator: what science it would do, what technology it would use, how big it would be, how much it would cost, where it might be built, who would use it, who would build it….

TESLA? What does TESLA mean?

"TeV Energy Superconducting Linear Accelerator." "TeV" stands for "trillion electron volts." It means that TESLA would have an energy of a million million electron volts—that's a lot.

What would it do?

Well, TESLA would be a linear collider, a particle accelerator creating trillions of very high-energy collisions between electrons and antimatter particles called positrons. The high energy of the collisions would give particle physicists a powerful new tool for exploring the most fundamental questions about matter, space and time—almost like recreating the Big Bang, but in miniature. Scientists have theories about matter, about why particles have mass, about how gravity fits into the picture, about dark matter and dark energy in the universe… Accelerators like TESLA give them a way to discover if their theories are true. TESLA would also create an powerful and precise new kind of x-ray laser called a free electron laser. The X-FEL would give structural biologists and materials scientists an unprecedented atomic-scale, three-dimensional imaging technology.

Why is TESLA here in Hamburg?

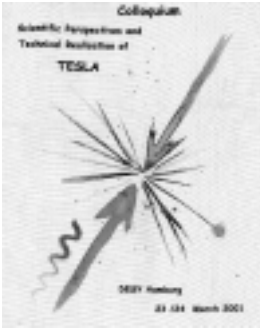
TESLA started out as the vision of an extraordinary physicist and a great man, Bjørn Wiik. He was the director of DESY from 1993 until he died in 1999. He had the idea for TESLA, and he inspired an international collaboration of scientists centered at DESY to bring it to life.

Photo by Judy Jackson

It's w-i-ide! Fermilab's David Finley and Peter Limon in a future beamline tunnel at DESY. Currently, the tunnel holds a public exhibit, including an aerial photo (on the wall at left) showing the proposed TESLA beamline. Hamburg residents can locate their homes in relation to the path of the proposed underground accelerator.

How big would TESLA be?

TESLA would stretch out in a thirty-three kilometer line, in a long tunnel from ten to thirty meters underground. If it were built here in Hamburg, the electron accelerator would start at DESY, and reach out toward the northwest, through the countryside toward the village of Ellerhoop in the district of Pinneberg. At the other end, the positron accelerator would start in Westerhorn. The electrons and positrons would collide underneath the outskirts of Ellerhoop.



TESLA *by* TAXI

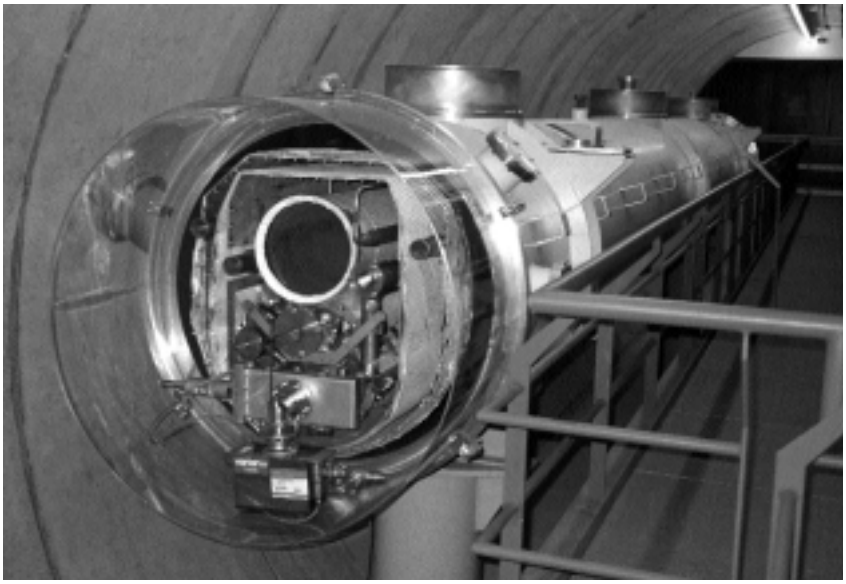


Photo by Judy Jackson

A display model of a superconducting TESLA cavity. In real life, the model is bright yellow.

At CERN?

At CERN, yes. Now the world's physicists are thinking about what and where the next accelerator will be. TESLA is one proposal, but it's not the only idea. Other collaborations in other countries have their own proposals. In the U.S., we also have ideas for new machines. No one knows yet exactly what or where the world's next accelerator will be. We do know that any new accelerator will have to be a truly international project. One thing that makes TESLA very interesting to scientists is that it uses superconducting technology to accelerate particles.

Superconducting?

Superconducting materials conduct electricity without losing energy. Superconducting accelerating structures can create high particle collision rates, high-power particle beams and small beam sizes—all good things in a particle accelerator. And superconductors save electricity. One of the great achievements of the TESLA collaboration is to develop superconducting accelerating structures that are powerful enough and cheap enough to form the basis for a realistic linear collider. It was no easy job!

How much would it cost?

The whole thing—the linear collider, the free-electron laser facility, and a particle physics detector to look at the particle collisions—would cost about 3.9 billion Euros, or 7.6 billion Deutschmarks, over ten years.

(Gasp!) No! Who would pay for it?

It would have to be an international project. DESY is making the assumption that half of the costs would come from the federal government of Germany, and the other half would come from foreign countries.

Really! Is that safe?

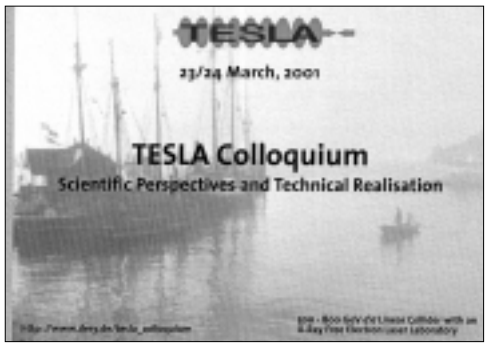
Yes, it would be completely safe. The collisions would have no effect on the soil or the water or the environment. The people who live above the tunnel would not know that anything was happening beneath them.

Now…is there a need for such a thing? Would scientists want to use it?

Scientists are always searching for the most advanced and most powerful tools for their research. Particle physicists need very high-energy accelerators; materials scientists and biologists need advanced imaging tools. If they built TESLA, scientists would come.

Are there other machines like this in the world, or would TESLA be the only one?

There are other accelerators. Back home in Chicago, we have the Tevatron, the most powerful particle accelerator in the world. There's a new one under construction—



There are so many problems now. The trees are dying, the animals are sick…. Is it a good idea to spend so much money on something like this?

That is a question that the German people and the German government will have to answer, as well as the governments of other nations. It's a big investment, and you're right, there are many other needs. But you could think about it this way: investing in basic science, the kind that happens at a particle accelerator, can sometimes help solve problems like disease and pollution. For example, the XFEL could allow biologists to watch a virus in the act of infecting a cell. That might lead to breakthroughs in preventing infections. We don't know exactly where the discoveries from an accelerator like TESLA will lead. We do know from experience that the more fundamental the knowledge we gain, the more profound will be its effects.

What do other countries think about TESLA? Do they think it's a good idea?

Scientists from other countries are very interested in TESLA. At the TESLA Colloquium this weekend, the organizers expected about two or three hundred scientists. In the end, more than 900 came, forty percent from outside Germany. That's one measure of worldwide interest. Everyone recognizes that the Design Report—the science, the technology, the planning and the communication—is a remarkable achievement. There was a strong sense of excitement at the colloquium.

So what happens next?

Next, the *Wissenschaftsrat*, the German Scientific Council, will study the design report and the TESLA project for about a year. Next summer they will make a report to the German federal government. Then, the government will decide on the TESLA Project. DESY estimates that, if the project is approved, it will take about eight years to build.

What do* YOU *think about TESLA?

I think that, as a citizen of Hamburg, you should be very proud of your high-energy physics laboratory, and proud of the people of DESY—for their remarkable accomplishments, for their absolute excellence in science and technology, and for the energy and spirit they bring to the world community of physicists in planning for the future. The TESLA Project is a perfect example.

Well, now I know what they do at DESY.

Why not take a tour and see for yourself?

Would that be okay? I was not too good in science at school.

They would be happy to see you. DESY loves company!

Okay, here we are. There's the Rathaus. I hope you enjoy Hamburg.

Danke. Auf wiedersehen!

Photo by Petra Folkerts

Fermilab contributes to TESLA

by Chad Boutin

Fermilab's longstanding collaboration with DESY-Hamburg has played a role in developing the TESLA Test Facility.

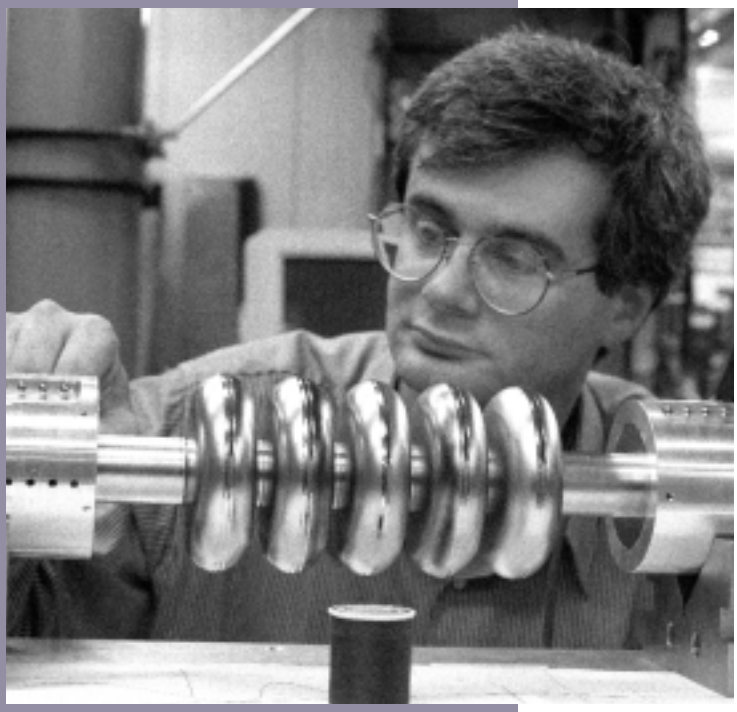
"Fermilab has contributed several pieces of equipment vital to research at TTF," said Helen Edwards of Fermilab's Beams Division and DESY. "Both the TESLA electron beam and its electrical power are provided by technology built at Fermilab."

In 1994, Edwards proposed that Fermilab provide the photoinjector for TTF. The source of electrons in TESLA's accelerator, the photoinjector is a strong laser gun that knocks electrons out of a target.

Fermilab also constructed equipment that powers radiofrequency (RF) cavities that accelerate the beam. Helen and her husband Don Edwards, of the Beams Division, have been involved with the TTF collaboration ever since.

"Fermilab contributed the modulators and couplers that feed power to the RF cavities," Don Edwards said. "You cannot just plug the RF cavities straight into a wall socket. It is necessary to modify what the electric company sends you."

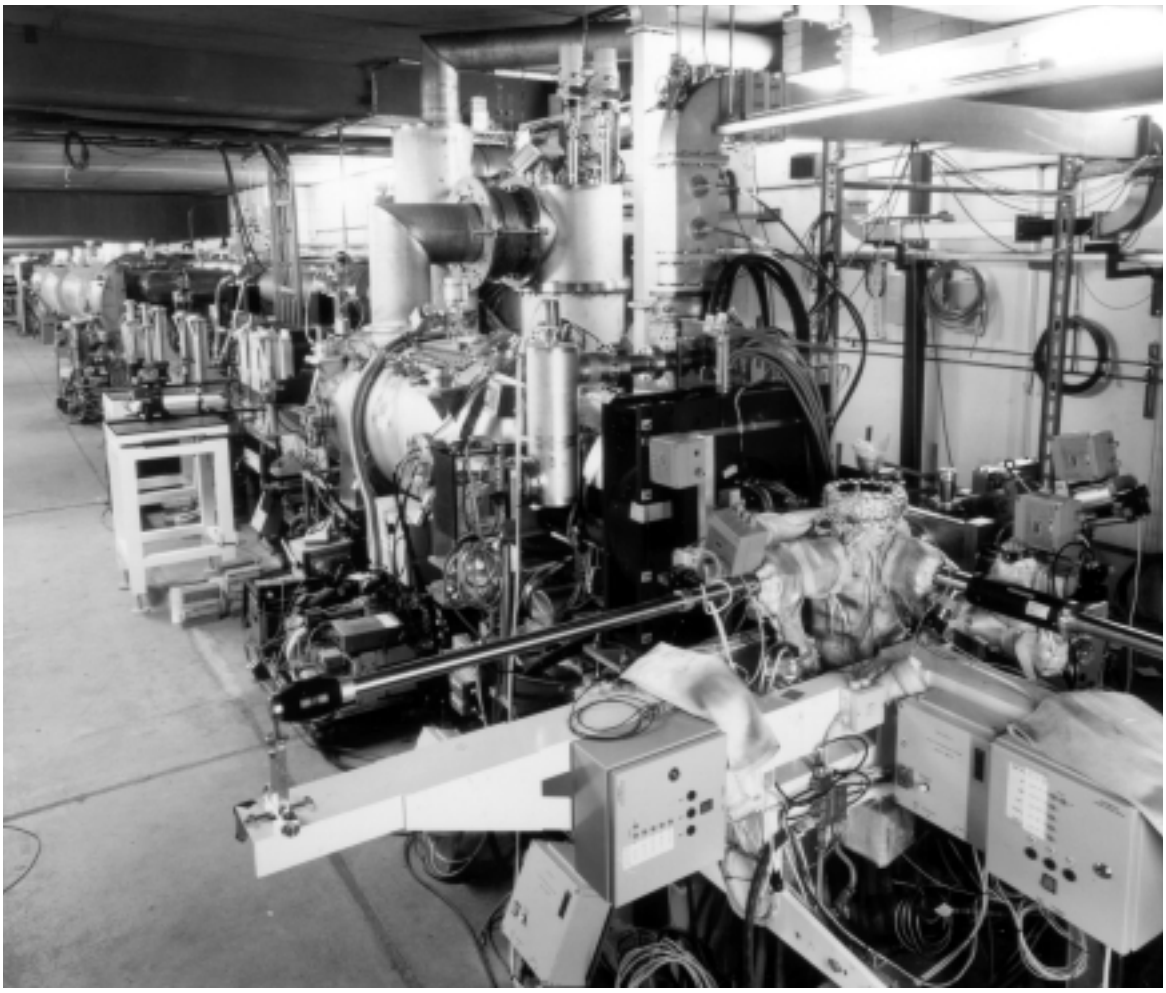
Fermilab physicist Leo Bellantoni setting up a test on the first superconducting RF cavity ever built at Fermilab.



The three modulators possess characteristics of both transformers and capacitors, first altering the AC current from the wall into DC and then sending it to the RF klystrons in controlled two-millisecond bursts. Even then, the power must pass from the warm environment we live in to the supercooled RF cavities, which are kept at about 2 kelvins, just above absolute zero, to power an electron beam. The RF couplers, built by Fermilab's Beams Division, incorporate a cryogenic design to transmit the power into the superconducting cavities without heat loss.

Testing the nine-chambered superconducting RF cavities that are the heart of the accelerator is difficult and expensive. When designers at TESLA were considering several cavity prototypes, Fermilab's Technical Division provided vertical dewars for testing.

"If you want to test the superconducting guts of the RF cavities, it's easier to just stick it in liquid helium," explained Fermilab physicist Dave Finley. "The vertical dewars are essentially big helium baths. You can try out each prototype and see which one works best."



DESY photo

Fermilab contributed components of the TESLA Test Facility, used to develop and test the new superconducting accelerator technology for the proposed TESLA project.

The Technical Division also developed and produced the magnets for use as a "chicane" at TTF. This device compresses the electron beam in time.

Helen Edwards emphasized that interlaboratory cooperation is a two-way street. Fermilab has received equipment for research from DESY among many other institutions.

Fermilab also constructed a second photoinjector for its own beam dynamics research.

"The superconducting cavity for our photoinjector at Fermilab was developed and built in Germany," Helen Edwards said. "We also use a German klystron to amplify our RF power. Other equipment comes from Italy, Cornell, Jefferson Lab and UCLA. This is a mixture of different people helping each other out."

The high-quality electron beam of TTF can be directed through a set of alternating dipole magnets called an undulator. The magnets make the electrons wiggle rapidly, emitting a high-energy coherent X-ray beam that can be used to probe the molecular world with unprecedented resolution.

"This new light source would enable advances in what I call the three M's: materials science, medicine and military technology," Finley said. "We hope an X-ray laser will come from this research that will allow scientists to take rapid pictures on the molecular scale. Among other things, this would actually allow movies of chemical reactions. It's never been done before. Companies would line up to use it."

PEDAL to the METAL

for new superconducting materials

Photo courtesy of Bell Labs

Bell Labs' Christian Kloc, Zhenan Bao and Ananth Dodabalapur (left to right) display the first superconducting plastic.

by Mike Perricone

Developments in superconducting materials are accelerating, from the first superconducting plastic to metals that could some day bring down the costs of accelerator magnets for high-energy physics. The pages of the scientific journal *Nature* have been full of possibilities.

"Right now, there's lots of scientific excitement in superconductivity," said David Larbalestier, director of the University of Wisconsin's Applied Superconductivity Center.

In the March 8 issue of *Nature*, New Jersey's Bell Laboratories announced the creation of the first superconducting plastic. Christian Kloc, Zhenen Bao and Ananth Dodabalapur of Bell Labs, along with three European colleagues, achieved superconductivity (at a temperature of about 2.6 kelvins) with a solution containing the plastic, polythiophene.

In the March 1 issue of *Nature*, a paper by Jun Akimitsu and colleagues described superconductivity at 39K in the simple compound magnesium boride (MgB_2). Again in the March 8 issue, Larbalestier and colleagues from Wisconsin and Princeton described their evaluation of the current-carrying capability of MgB_2. This material, Larbalestier and colleagues wrote, "offers the possibility of a new class of low-cost, high-performance superconducting materials for magnets and electronic applications."

Magnesium diboride seems to act in ways similar to other low-temperature metallic superconductors. For example, its grain boundaries do not exhibit weakened superconductivity that blocks current flow from crystal to crystal, a quality that makes the high-temperature ceramic superconductors susceptible to weak magnetic fields. But magnesium diboride operates at a much higher temperature (39K vs. 18K) than another developmentally promising magnet material, niobium-tin (Nb_3Sn). The higher the temperature, the lower the need for liquid helium cooling, and the lower the cost of operating superconducting accelerator magnets.

Larbalestier concedes there are two immediate obstacles to using magnesium diboride for magnets. First, although the critical temperature (T_c, the temperature at which superconducting occurs) is much higher than that of niobium-titanium (Nb-Ti; 9K) or niobium-tin (Nb_3Sn; 18K), it is too low to replace ceramic high-temperature superconductors (HTS) which have T_c ranging from 90 to 110K. Second, the strengths of the magnetic field at which bulk supercurrents disappear (the irreversibility field H*), and which wipe out superconductivity (H_{c2}, or "upper critical field"), are too low to replace the niobium-based superconductors. But there is hope.

"It should be possible to raise the upper critical field by alloying," Larbalestier said, "just as is done by adding titanium to niobium to make the niobium-titanium from which the Tevatron is made."

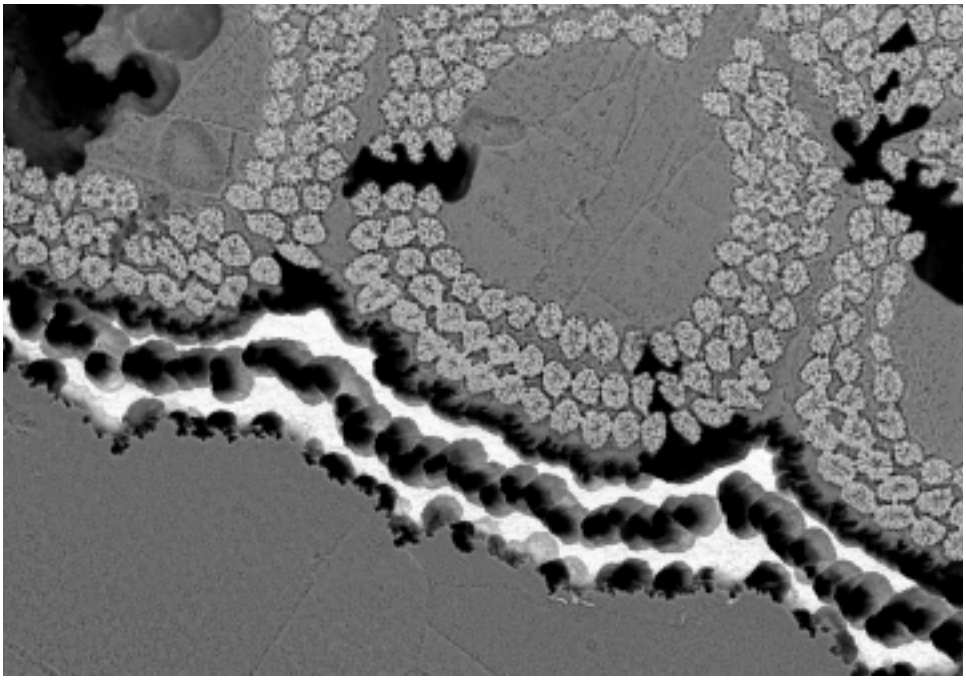


Image courtesy of Technical Division

After cooking at high temperature (650-700°C), a starting strand of niobium-tin-copper composite reacts to form niobium-tin (Nb_3Sn). The copper has become bronze, and the white area is a barrier separating the subelements from the pure outside copper.

Larbalestier pointed out that without titanium, the upper critical field for niobium is about 0.3 tesla; with titanium added, the value increases to 11 tesla. In a second paper recently submitted to *Nature*, Larbalestier and other colleagues showed that thin films of magnesium boride demonstrate improved irreversibility fields. And he proposed that magnesium diboride could be highly useful for electronic applications where the magnetic field is not a factor.

If magnesium diboride proves useful for accelerator magnets, at a low cost, that development couldn't come at a better time.

"The state-of-the-art material for accelerator magnets is niobium titanium," said Peter Limon, head of Fermilab's Technical Division. "But we're reaching the limits of that material, with the Large Hadron Collider quadrupoles we're making at Fermilab and the LHC dipoles being made in Europe. We need new materials to go higher in field strength."

The most promising prospect so far is niobium-tin alloy (Nb_3Sn), which Limon described as a better performer than niobium-titanium, but with the drawbacks of being brittle and expensive. Accelerators don't have the market leverage of biomedical technology, where the magnetic resonance imaging industry drives the market for niobium-titanium superconducting wire. Limon said the peak demands of LHC production would match MRI demands for a year or two, but not longer.

"The problem we have is that to drive a commercial market, you need a continuous demand," Limon said. "Our demand is a pulse. It may be a huge pulse, lasting a few years, but it's still a pulse."

Larbalestier said it is too early to tell the role plastics might play in magnets and, by extension, the market.

"So far, only metallic superconductors are applicable for superconducting magnets or cavities," he said. "But all of us in the applied community work off the basic science of the type that the Bell Labs group is doing. Magnesium diboride and polythiophene are both valuable."

Polymer plastics, chemical molecules with long strings of carbon atoms, came late to the electrical game. Conducting organic polymers were discovered in the mid-1970s, leading to the 2000 Nobel Prize in Chemistry for Alan J. Heeger of the University of California at Santa Barbara, Alan G. MacDiarmid of the University of Pennsylvania, and Hideki Shirakawa of Japan's University of Tsukuba.

Plastics are cheap to make, and they're everywhere, creating immediate excitement about superconducting possibilities.

"With the method we used, many organic materials may potentially be made superconducting now," Bao commented.

Stay tuned for more developments, and more papers.

Super conductivity

by Kurt Riesselmann

Electrification is the greatest engineering achievement of the 20th century, according to a list published by the National Academy of Engineering last year. Delivering electricity to homes and businesses and powering tools and appliances greatly influences our daily lives—just ask Californians.

Getting electrical power to consumers is an energy-consuming effort. Currents flowing through electrical wires encounter electrical resistance, a microscopic form of friction, which results in loss of energy.

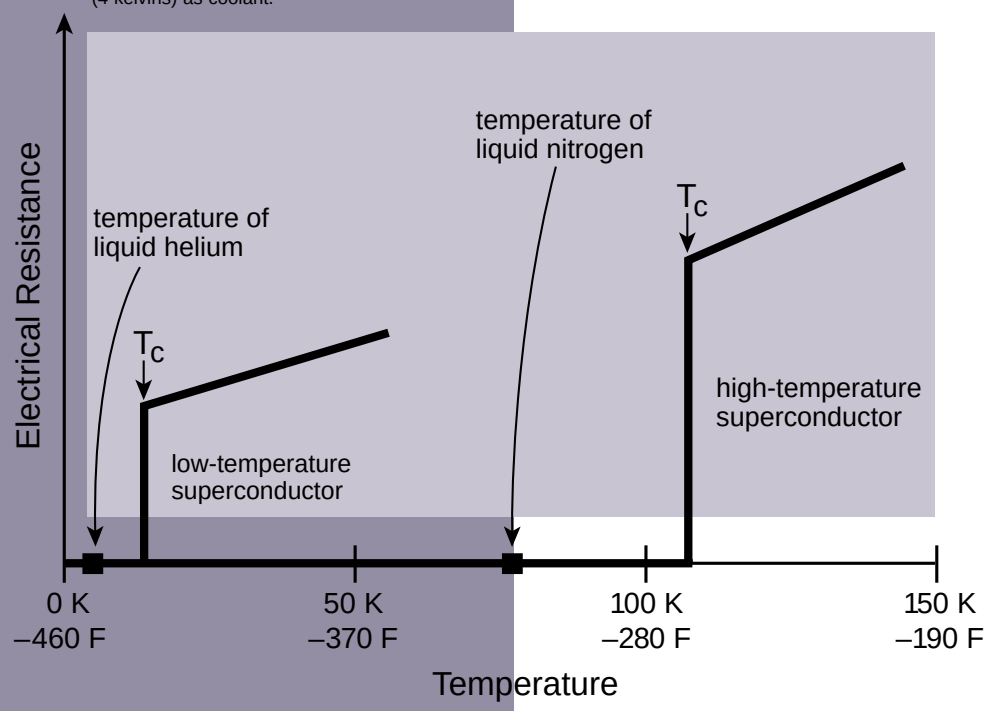
Eliminating electrical resistance in wires and electrical components could be the success story of the future. Thousands of scientists around the world are working on new materials that promise to revolutionize our world based on an intriguing phenomenon: superconductivity.

Superconductors transport electrical currents without electrical resistance and hence without wasting energy. Scientists have circulated electrical currents for years on end through a loop made of superconducting material, with no external power supply. Sophisticated experiments have revealed that such supercurrents can last for 100,000 years, in contrast to the one-second lifetime of a current in a nonsuperconducting coil.

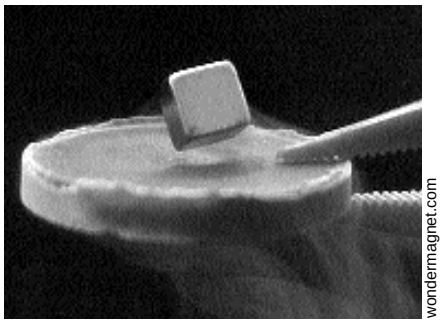
So why hasn't the superconducting revolution happened yet?

The superconducting materials known to scientists require low operating temperatures. Very low. To be precise: colder than –209 degrees Fahrenheit (139 kelvins). At present, that's the world record for the highest critical temperature (T_c) below which a carefully engineered compound of mercury, thallium, barium, calcium, copper and oxygen becomes superconducting. The new crystalline material, characterized as $Hg_{0,2}Tl_{0,8}Ca_2Ba_2Cu_3O$, is the latest flagship of a new breed of materials, known as high temperature superconductors, developed since 1986.

Many metals, which normally show electrical resistance, become superconducting at very low critical temperatures T_c. Since 1986, physicists have discovered new superconducting materials that lose electrical resistance at much higher T_c. They operate with much cheaper liquid nitrogen (boiling temperature: 77 kelvins) instead of liquid helium (4 kelvins) as coolant.



A COOL phenomenon that could *change the world*



wondermagnet.com

A magnetic cube floats above a superconducting disc: The force prohibiting the cube's magnetic field from entering the disc's interior is stronger than the gravitational force pulling the cube down.

"Superconductivity in conventional superconductors has been very well understood for a long time," said Steven Kivelson, professor of theoretical physics at UCLA. The theory of high temperature superconductivity, however, is still a work in progress.

"Physicists are able to describe the macroscopic phenomena of HTS," he said. "The microscopic mechanism that underlies it is not understood."

The advent of HTS materials, which are all insulators at room temperature, came as a total surprise. It greatly increased the pre-1986 record critical temperature, marked at –418°F (23K), for what are now called low temperature superconductors. Scientists hope to achieve another quantum leap in the future, possibly finding materials that are superconducting at room temperature.

It started with mercury

In 1911, Dutch physicist Heike Kamerlingh Onnes studied the temperature dependence of electrical resistance. His laboratory in Leiden was one of the few places in the world that had the equipment to cool objects to ultracold temperatures. Experimenting with mercury, Kamerlingh Onnes observed that its conductivity rose sharply when the temperature dropped below –452°F (4K). At and below this critical temperature, the electrical resistance of mercury vanished—superconductivity had been observed for the first time. The sudden drop in resistance (see graphic), which allows for the conductivity to go up, is characteristic for all types of superconductors discovered so far.

Over time, physicists discovered further remarkable properties of superconductors. In 1933, two German scientists discovered that superconducting materials expel magnetic fields from the interior when temperatures drop below T_c. A probe already in a superconducting state remains "immune" to magnetic field penetration as long as the strength of the external magnetic field is below a critical value H_c. Called the Meissner effect, the resulting forces can be strong enough to levitate a small magnet—or even a train (see photos).

Once an external field becomes stronger than H_c, it is able to force its way into the superconducting material. Depending on the type of superconductor, the material may immediately turn "normal conducting" and will be completely penetrated by the magnetic field (type I superconductors, which include many metals, with H_c typically of the order of 0.1 tesla). Or, it may only allow isolated magnetic vortices to enter its interior, surrounding them with superconducting regions (type II superconductors). This mixed state, observed in many HTS materials, retains some superconducting properties. It requires an even stronger magnetic field, indicated by a critical strength H_{c2} (usually tens of teslas), to completely send a type II superconductor back to its normal non-superconducting state while its temperature remains below T_c.

Using superconducting magnets, this Japanese Maglev train reached 345 miles per hour (552 km/h) on April 14, 1999.

Powerful magnets – at almost no cost

Superconducting wire is the ideal material for building powerful electromagnets that consume no electrical power. Finding the right kind of superconducting material, however, has taken many years of R&D, and the search for better materials and improved production processes continues. Physicists are looking for superconductors that can carry high electrical currents (thousands of amperes) in the presence of strong magnetic fields, requiring type II superconductors. On top of this, the material must be flexible enough for forming a coil – a criterion that many of the brittle HTS materials do not yet satisfy. Scientists therefore rely on robust low temperature type II superconductors made of niobium and titanium (NbTi) or, more recently, niobium and tin (Nb_3Sn). Unfortunately, the energy

Superconductivity

savings created by superconducting electromagnets is somewhat reduced by the electrical power needed to cool the superconductors with liquid helium.

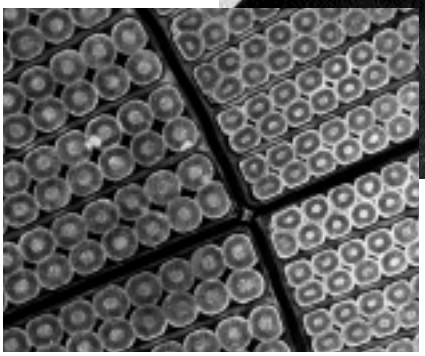
Powerful superconducting magnets, with multi-tesla fields, have a wide range of applications:

- magnetic resonance imaging (MRI)
- levitated vehicles
- energy storage
- plasma confinement for fusion research
- high-energy particle colliders

The discovery of HTS has spurred the development of superconducting technologies that go beyond electromagnetic applications. Cooling HTS with commonly available liquid nitrogen, which boils at –321°F (77K), is about 500 times cheaper than cooling LTS with liquid helium, which boils at – 452°F (4K). This cost-saving progress in technology has caught the attention of power utilities around the world, and the first projects are underway to install superconducting cables as parts of the electrical distribution grid. In a recent project in Detroit, three thin superconducting cables, weighing 250 pounds, replaced nine conventional copper cables of 18,000 pounds.

New applications continue to arise. Thin films of superconducting material, for example, are used in a variety of electronic devices, including SQUIDs, instruments capable of detecting even the weakest electromagnetic fields, and ultra-high-performance filters, which pass or block selected frequencies, an important technology in wireless communications and other areas.

With so many superconductor applications already in operation or being developed, it is almost impossible to imagine the impact the discovery of room-temperature superconductors would have. One thing, however, seems clear: Its discovery would provide the basis for many of the greatest engineering achievements of the 21st century.



One-foot-diameter cylinders (right) are stretched to yield miles of one-millimeter superconducting wires. About 20 of them are bundled together (top insert). Bundles are stacked together (bottom insert) to form powerful magnetic coils.

Photos by Reidar Hahn

The physics of superconductivity at the microscopic scale is too complex and subtle for simple explanation. For the adventurous, these websites provide more insight.

Information on the History and Theory of Superconductivity: www.superconductors.org/

Superconductivity Concepts Map: hyperphysics.phy-astr.gsu.edu/hbase/solids/supcon.html

DOE Superconductivity Program: www.eren.doe.gov/superconductivity/

CALENDAR

Website for Fermilab events: http://www.fnal.gov/faw/events.html

FERMILAB ARTS SERIES

Choreographer's Showcase

Featuring Hubbard Street 2

April 21, 2001, 8 p.m. $17/$9 for ages 18 and under.

All Fermilab Arts & Lecture Series events take place in Ramsey Auditorium.

For tickets or further information, please call our box office at 630-840-ARTS weekdays between 9 a.m. and 4 p.m.

ONGOING / NALWO

■ Free English classes in the Users' Center for FNAL guests, visitors and their spouses. The schedule is: Monday and Friday, 9:30 a.m. - 11:00 a.m. Separate classes for both beginners and advanced students.

■ May 10, 2001, 10:30am: NALWO invites all women to an on-site Spring Prairie Walk; please see http://www.fnal.gov/orgs/nalwo/prairiewalk.html or call Sue, x5059, for more information.

BOOK FAIR

Wilson Hall Atrium
April 17 - 7:00 a.m. - 3:30 p.m.
April 18 - 9:00 a.m. - 5:30 p.m.

Recreation Bookorp Inc. will offer quality books, stationary, photo albums, toys and much more at discount prices.

SUMMER DAY CAMP

Registration for the Children's Summer Day Camp begins March 1 with a deadline of March 30. The session dates for the Children's Summer Day Camp are: Session I - June 18 - July 6; Session II - July 9 - July 27; Session III - July 30 - August 17. Information, booklet and registration form can be found in the Recreation Office or on our web page, http://fnalpubs.fnal.gov/benedept/recreation/campbrochure.html.

DANCING

■ International folk dancing, Thursdays, 7:30-10 p.m., Village Barn. Scottish country dancing, Tuesdays, 7:30 - 10 p.m., Village Barn. Newcomers always welcome. Call Mady, 630-584-0825 or Doug, x8194, or email folkdance@fnal.gov.

■ The Fermilab Barn Dance series, featuring traditional square and contra dances in the Fermilab Village barn, presents barn dances on Sunday, Admission is $5 for adults, $2 for age 12-18, and free for under 12 years old. Contact Dave Harding (x2971, harding@fnal.gov) or Lynn Garren (x2061, garren@fnal.gov) or check the WebPages at http://www.fnal.gov/orgs/folkclub/ .

CLEAN-UP

■ Join the Fermilab Third Thursday lunchtime clean-up beginning April 19, 11:45 a.m. to 1:30 p.m. For more information: www.fnal.gov/pub/news/cleanup.html

DASTOW 2001

Thursday, April 26

Daughters and Sons to Work day at Fermilab (DASTOW 2001) will be held on Thursday, April 26, starting with the annual group photo at 8:45 AM. Kids will learn to escape from a simulated burning building, set up by Fermilab's Fire Department. Jerry Zimmerman will offer two presentations of his supercool Cryo Show. Girls and their parents can learn why they should "Go For It!" in science and technology. Tom Peterson talks about "The Butterflies of Fermilab." The Buffalo Barn again is open for viewing, as is the Science Education Center, where you can make your own web page. Collect a commemorative poster at the end of the day. For more information, contact Judy Treend in Public Affairs (x3351, email treend@fnal.gov). Check out the DASTOW web page: www.fnal.gov/faw/dastow.

ARBOR DAY

Thursday, April 26

Fermilab's Roads and Grounds Department will hold a picnic lunch and tree planting to celebrate Arbor Day, starting at 11:30 a.m. See the DASTOW webpage for information.

MILESTONES

BORN

■ [redacted]

ELECTED

■ Robert Johnson (ID 08162, BS-MA-Purchasing), as an Elgin Township trustee.

■ Warren Cannon (retiree, Human Resources), to the West Aurora School Board.

■ Michael Fortner, Northern Illinois University user, as mayor of West Chicago.

RETIRING

■ Barbara Bennett (ID 3698 BD-Environmental Safety & Health) effective March 30.

■ Manuel Martin (ID 4678 PPD-Engineering & Tech Teams) May 4.

Chez Léon MENU

LUNCH SERVED FROM
11:30 A.M. TO 1 P.M.
$8/PERSON

DINNER SERVED AT 7 P.M.
$20/PERSON

FOR RESERVATIONS, CALL x4512
CAKES FOR SPECIAL OCCASIONS
DIETARY RESTRICTIONS
CONTACT TITA, x3524
HTTP://WWW.FNAL.GOV/FAW/EVENTS/MENUS.HTML

LUNCH
WEDNESDAY, APRIL 18

Dominican Beef Salad
Potato Fonseca
Mango Flan

DINNER
THURSDAY, APRIL 19

Minestrone with
Sweet Sausage and Tortellini
Veal Chops with Sherry
and Lemon Marmalade
Barley, Corn and Red Pepper
Green Rice
Strawberry Shortcake

LUNCH
WEDNESDAY, APRIL 25

Salmon with Dill Sauce
Bow Tie Pasta with Vegetables
Marzipan Cake

DINNER
THURSDAY, APRIL 26

Closed

FERMI NEWS

FERMILAB
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The deadline for the Friday, April 27, 2001, issue is Tuesday, April 17, 2001. Please send classified ads and story ideas by mail to the Public Affairs Office, MS 206, Fermilab, P.O. Box 500, Batavia, IL 60510, or by e-mail to ferminews@fnal.gov. Letters from readers are welcome. Please include your name and daytime phone number.

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CLASSIFIEDS

FOR SALE

■ '98 Wilderness Travel Trailer, 22′ Lite, excellent/like new, options, loaded, sleeps 6, $8,300. Call Tom x8510 or (630)978-3282, or sperry@fnal.gov.

■ '97 Dodge Neon Highline 4 door sedan, green, 4 cyl, PS, AT, AC, dual air bags, valet remote RF auto-start feature, Jensen CD/cassette stereo system, 3 year or 37,500 mile bumper to bumper limited warranty, Carfax clean title history guarantee, 56K miles, excellent condition, $6,995 o.bo. Call Dave at 630-375-1477 home or 630-464-8078 cell phone.

■ '94 Grand Prix SE V6 2dr blue with gray interior 82K miles, excellent condition. $5,900 O.B.O. Contact Greg 630-272-5985.

■ '92 Mazda MX3 GS V6, 97k mi, good cond., well maintained, drives great, one owner. $3,000 o.b.o.. Call x6736 or 630-692-1701, leer@fnal.gov.

■ '84 Ford conversion van, 70k, good motor, new tires $200, 630-553-9464.

■ '77 vintage Dodge Charger, special edition, 163K, good condition, $2,000 o.b.o., 630-553-9464.

■ All aluminum utility trailer; 6′ x 10′ low aluminum non slip platform with outside fenders; 2200# torsion axle; 13″ wheels with a spare tire; full width aluminum ramp/tail gate; has stake pockets for attaching side boards; comes with an aluminum motorcycle ramp and 3 wheel chocks. The trailer is in excellent condition, is light weight, can be towed with a light vehicle, has about 5000 miles on it and is garage kept by the original owner. Asking $1,200. Call Rap @ 879-5506 or x3302.

■ Mac PowerPC Performa 6400/180, 72 MB RAM, 6.4 GB HD, tower/woofer, 15″ monitor/speakers, ex modem, Epson 850 ink jet printer, HP scanner, 100 MB Zip, OS 9, WORD, EXCEL, Appleworks, Hypercard. No known problems, stable system. Never exposed to winter salt, used in Florida. ALL $700 x3769, Flora@FNAL.gov

■ Rainbow SE Vacuum Cleaner with Power Nozzle and Aqua Mate, asking $500.00 o.b.o. bennett@fnal.gov

■ Golf Clubs, Orlimar Trimetal Woods with graphite shafts,one year old, like new. 14+ 3wood and 18+ 5wood. $125 each. Jim x4293 or 585-0907.

■ Nordic Track WalkFit Treadmill, series 3000 all extras included. Folds down for easy storage. Asking $149, call Julie 630-879-2684.

FOR RENT

■ 2-Bedroom apartment with new refrigerator, stove, air conditioner, and new tile floor. Includes carpeting in living room and bedrooms with drapes/shades on windows. Large bathroom, gas heating and water included. Tenant pays for own electricity. Laundry room facilities available. $795, 1 year lease. Phone 630-584-4686 or 630/573-4619; ask for Barb.

■ 4 Bdrm home w/2 car garage. Excellent neighborhood in Aurora w/private road. $1,100 per month plus one month security deposit. Utilities not included in rent. As630-801-1775.

■ Spacious bedroom on independent floor; use of kitchen and laundry; big living room not used by owner; garage; in quiet residential Naperville. 10 miles from Lab. $395/mo. Available end of April.

HOUSE FOR SALE

■ In very popular Batavia neighborhood, 2-story house built in 1992. Close to school, Fermilab and shopping. Home is on a cul-de-sac with a large lot and water view. Loads of space, 4 bedrooms, 2.1 baths, 2-car garage. The master suite boasts a deluxe bath with skylight. Home has two phone lines in every room and ISDN connection. Excellent value at $224,900. Email shekhar@att.net.

LOTS FOR SALE

■ Site includes trees planted last fall and a field creek in the back section of the property. Site is situated in a development in the Lee township and is located just about 2 miles west of Lee county and about 2 miles north of HWY 30.Asking $62,500. Call 815-627-9538 or email chappa@fnal.gov for property description and list of covenants.

■ Two acres plus, agricultural lot, with building permit, on Immanuel Road, Yorkville, $80,000 630-553-9464.

LAWN MAINTENANCE

■ Attention homeowners in West Aurora, North Aurora, and Batavia, excellent lawn maintenance available, call Roger 630-859-3789.

FURNITURE REFINISHING

■ Repairs and restorations, pick-up and delivery available. 815-695-5460.

ARTS & CRAFTS SHOW

■ Attention Fermilab Artists and Artisans: Now is the time to show us your artistic side! The Employees' Arts & Crafts Show will take place in the 2nd Floor Gallery of Wilson Hall from May 14 to June 15. All Fermilab employees, visiting scientists, retired employees, contractors and their immediate families are encouraged to enter. The last exhibit featured an eclectic combination of photographs, prints, paintings, sculptures, weavings, quilts and jewelry. Application forms at the Wilson Hall Atrium desk. Application deadline April 26. Work must be dropped off on Wednesday May 4, 2001.

NOON BIBLE CLASSES

■ Need wisdom, want understanding? Take a 1 year study of the scriptures. Wednesdays at 12 noon in the Huddle. For information call x4432, Jeff Ruffin.

LETTERS TO THE EDITOR

To FERMINEWS:

In the March 30 issue of *FERMINEWS*, Judy Jackson mentioned, in her article entitled, *"Why is a Sammy Sosa Home Run Like a Higgs Boson? Or, What's a Meta For?"* an elusive metaphor. Perhaps it's true that "the truth is a hard deer to hunt," but when hunting for quotations, Judy should have turned to her local Fermilab librarians, who could have told her that the quotation is by Stephen Vincent Benet in his short story, By the Waters of Babylon. Perhaps it is a good thing for Fermilab that the truth is a hard deer to hunt, for the quotation continues, "...If you eat too much truth at once, you may die of the truth."

Beth Anderson
Fermilab Information Resources Manager

To FERMINEWS:

I very much enjoyed your March 30th article *"Why Is A Sammy Sosa Home Run Like A Higgs Boson?"* Author Judy Jackson writes very clearly! I'm not a physicist or an engineer but I have been working here 21 years. From an outsider's point of view I feel I know a great deal about the lab, though from a physicist's or engineer's point of view, I suspect I know very little. But your article on metaphors was great for a "knowledgeable/un-knowledgeable" person like myself. So often I'm approached, as I suspect many of us are, and asked, "What is Fermilab, and what do you people do there?" Personally, I like to elaborate on a giant microscope metaphor. However, the next question always has me stumped: "What benefits have your discoveries produced in our world besides knowledge?" Do you think Judy could write about the benefits of our research? I would appreciate it for my personal public relations. I love taking people around the lab on tours, but I am always asked that question and really need to give them a more accurate answer.

Steve Conlon
BD-Accelerator Controls Dept.

http://www.fnal.gov/pub/ferminews/

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